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Groundwater Irrigation Development and Sustainability in Raya Valley Northern Ethiopia

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Abstract
Dependence on rain-fed agriculture not only reduces productivity but also greatly increases growth volatility of the agriculture sector and the vulnerability of the poor. Use of groundwater for irrigation is rapidly increasing since recently to bring numerous socioeconomic benefits to smallholder farmers by growing more crops and minimize the impact of rainfall variability and seasonal drought. Irrigation can improve crop production, reduce yield variability and increase income of the beneficiary farm households. Installation of groundwater irrigation system requires large initial investments and once installed is relatively irreversible for reasonably long-time. Irrigation development including groundwater irrigation has taken as one of the pillars for the modernization of the agriculture sector in Ethiopia. Irrigation development programme is one of the pro-poor investments undertaken by the state in Ethiopia and such a pro-poor public investment is crucial to the farm community at grassroots level. Raya Valley is one of the potential areas for groundwater irrigation development to compensate the frequent drought happening due to weather variability. The development of groundwater irrigation infrastructure has both positive and negative effects subject to efficient and sustainable use of the resource by the beneficiary farm households and their water user associations (WUAs).

Key Words: Development, Groundwater, Irrigation, Farm households, Water User Associations

1. Introduction

Irrigation development has taken as one of the pillars for the modernization of the agriculture sector in Ethiopia and conceptualized by the government as the main instrument for operationalizing the long-term ADLI development strategy (MoWR, 2002). Irrigation development is prioritized/considered recently as one of the alternative strategies to fight against poverty and food insecurity, income generation, livelihood improvement and development as a whole both at household and national level (Awulachew, et al., 2007). Irrigated agriculture has both multi-dimensional benefits for development and negative consequences (i.e. environmental effects and social instability) subject to sustainable management and utilization of the resource or not (Awulachew, et al., 2007; Dinka, et al., 2014).

In Ethiopia, agriculture has taken as an engine of growth and considered as the important tools of equitable distribution of rural assets (agricultural land) to accelerate the use of rural technology and support the non-agricultural sector. Furthermore, agriculture is the mainstay of the Ethiopian economy in terms of income, employment, and generation of export revenue (Awulachew & Ayana, 2011). Ethiopia has a wealth of opportunities to increase irrigation and the country has 12 major river basins with annual surface runoff volume of 124.5km^3 (MoWR, 2002; Awulachew, et al., 2007). The potential cultivable land area of the country estimates vary between 30 to70 million hectare (Mha) and currently about 15 to 16.5Mha of land is under cultivation. Its estimated total irrigation potential is about 5.3Mha of which 3.7Mha can be developed using surface water sources, 1.1Mha can develop using groundwater sources, and the remaining 0.5Mha can be developed using rainwater management. Irrigation contributes to rapid transformation of the agricultural sector in particular and economic transformation in general. The current irrigation development in Ethiopia is about 0.7Mha across the country (Awulachew, et al., 2010; Awulachew & Ayana, 2011).

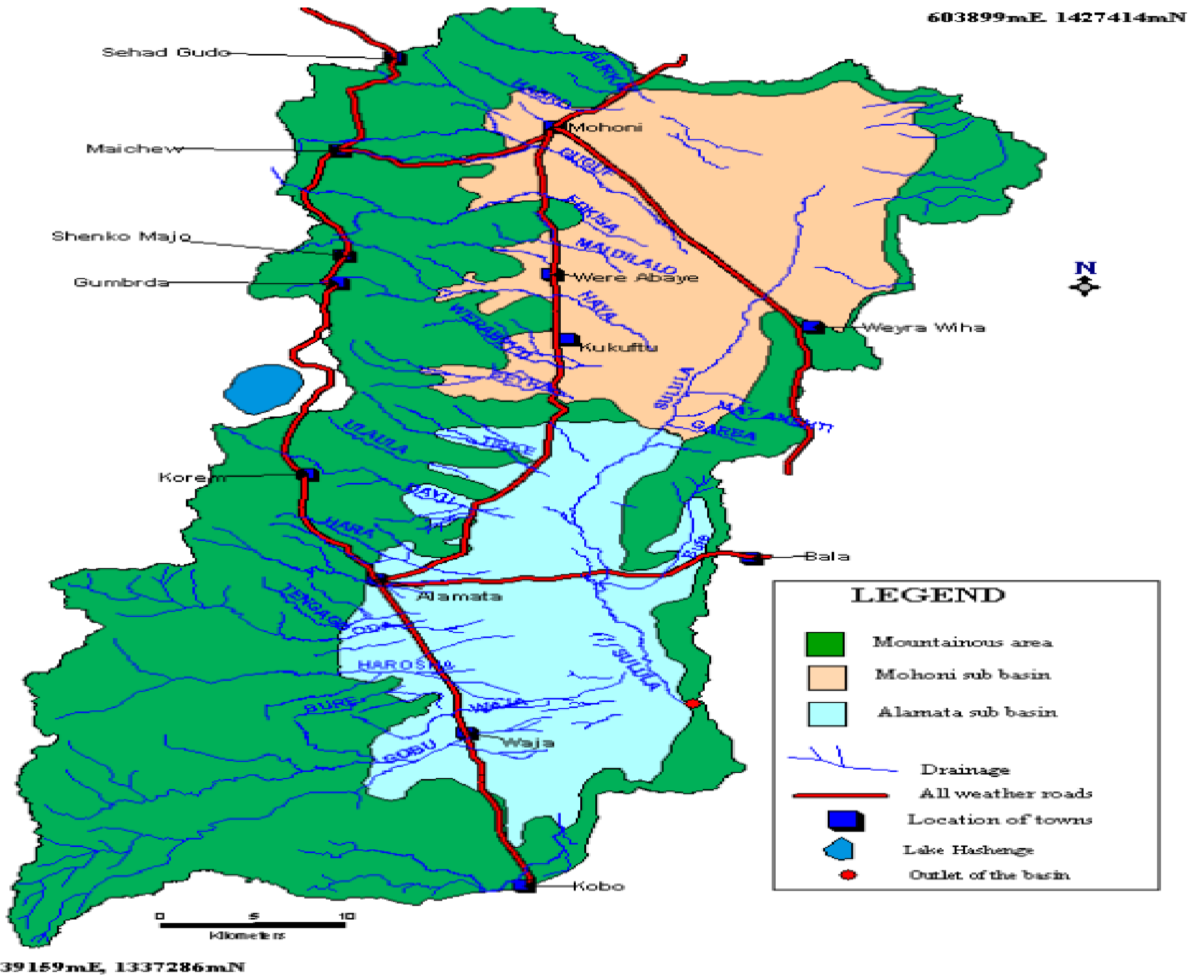
Yet Ethiopia's groundwater potential for irrigation remains uncharted and underdeveloped. The development of groundwater, in particular shallow well groundwater, for small-scale irrigation development at national and regional level are importantly and seen as a major avenue for rural poverty reduction. There are broad plans and visions about water resources for irrigation to augment irrigated plots via using different sources or technologies (van Steenbergen, et al., 2015). Groundwater irrigation has emerged as a strategy for economic growth, poverty reduction, and climate change adaptation by rural households although the capacity of groundwater aquifers to buffer climate change events depends on the storage and annual recharge (Kebede, 2010). Groundwater irrigation development is one of the means of escaping the smallholder farmers from nature (rainfall) dependent agricultural production system. Currently the development of small-scale groundwater irrigation receives a better attention throughout the country (MoFED, 2010). Small-scale groundwater irrigation can bring sustainable agricultural and economic development without sever effect on the environment given the sustainable management of the resource. There are many technologies and techniques in Ethiopia to extract water for irrigation purpose. Some of them are: macro-dams or reservoirs, river and stream diversions, groundwater and hand-dug wells, lake and river pumping, rainwater harvesting in traditional ponds (kurie in Amharic), spate irrigation, motorized (treadle) pumps, and sprinkler and drip irrigation systems.

2. Description of Raya Valley and Methods of the Study

In Northern Ethiopia, where rainfall is scarce with uneven distribution, groundwater is the main source for irrigation to meet the agricultural requirement of the smallholder farmers. Raya valley is among the areas in Northern Ethiopia where groundwater is believed to exist in a significant amount. The Raya valley is an intermountain plain covering parts of Southern Tigray Regional State, which is one of the most agriculturally potential areas in the region with good groundwater potential characterized by deep and fertile soil suitable for agriculture because of aged old alluvial deposition. Then, Raya valley has considered as one of a "development corridor" by the regional state where commercial agriculture can develop using the existing groundwater irrigation potential. Despite its potential, the area has been suffering from drought due to weather variability. At present food-insecurity is still a challenge in the area with the majority of farmers depending on relatively low productivity of seasonal spate irrigation and rain-fed farming practices. Spate irrigation is one of the traditional practices employed by farmers in Raya valley areas to supplement rain-fed agriculture.

The plain area of the Raya valley covers Raya Alamata and Raya Azebo Woredas (see Figure 1). The surface water catchment of the valley has an area of 2,576km^2. The altitude ranges between 3,600masl in the mountain ranges and 1,400masl in the inter-mountain valley plain (Raya valley alluvial aquifer). The Raya valley alluvial aquifer is part of the Selen-Wuha River surface water catchment of an inter-mountain plain, which is part of the interconnected valleys of the Ethiopian rift valley system. It has a total area of 1,227km^2, a trough bounded by the Ethiopian plateau and rift escarpment (western escarpment) at the west and Chercher Mountains in the east. The Raya valley plain alluvial aquifer is composed of loosely compacted sedimentary basin fill deposits (Moges, 2012).

Figure 1 Error! Reference source not found.**: Base map of the study area (Raya Valley)**

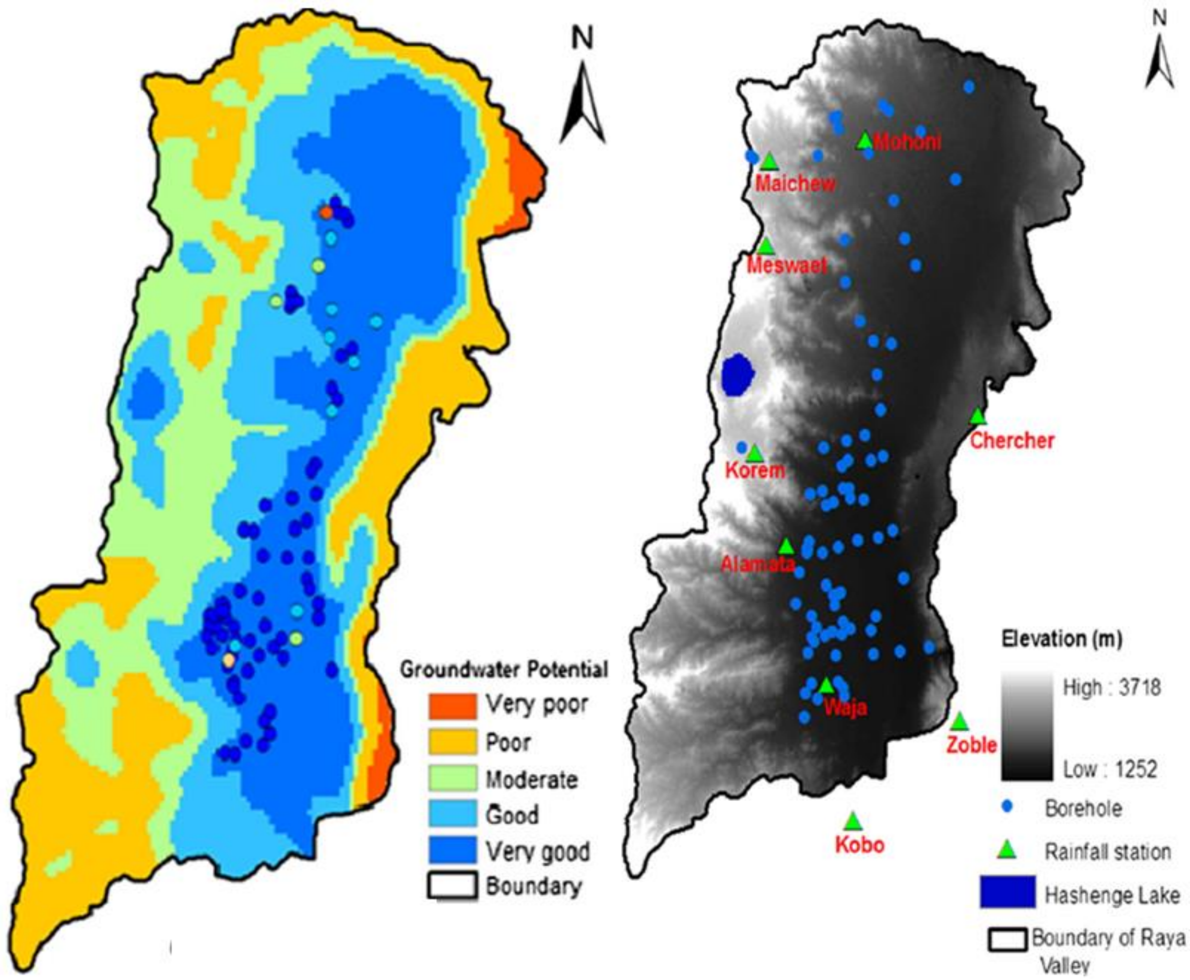


Source: Adapted from Hagos (2010)

Different studies asserted that the Raya valley has a groundwater potential that can develop for modern smallholder irrigation in the region. Though the study of the Raya valley for groundwater irrigation purpose dates back to the early 1970's; Relief Society of Tigray (1996) in collaboration with Tigray Regional State conducted the first intensive and integrated study of the valley. Relief Society of Tigray estimated the groundwater reserve in Raya valley was about 7.152billion cubic meters (BCM) and the recharge potential is about 85million cubic meter (MCM) per year (Relief Society of Tigray, 1996). Followed this study, Raya valley plain alluvial aquifer groundwater modelling carried out by Ministry of Water Resource (2008) to determine the sustainable exploitable groundwater potential resources in the valley. The approximate exploitable groundwater resource in the study area is estimated about130MCM per year with its total groundwater reserve 7.2BCM. The average groundwater recharge in the project area estimated to be about 84MCM per year. Almost all the water samples analysed from the groundwater are excellently suitable for irrigation (WWDSE, 2008). Furthermore, Moges (2012) has made an assessment about the groundwater potentials in the study area and his finding was consistent with WWDSE findings and the groundwater potential reaches about 7.2BCM. Estimated exploitable groundwater reaches about 160MCM per year in the study area (Moges, 2012). This implies there is no significant difference in the estimation of groundwater potential for irrigation in the study area. All confirmed that, the valley has a remarkable irrigation potential for groundwater irrigation purpose.

To tap this huge potential resource, the "Integrated Raya Valley Development Programme Project" or the "Golgol Raya Development Project" had initiated in early 2000s.This development project places groundwater irrigation as central to integrate crop, livestock, and soil and water conservation components in a holistic way to ensure sustainability. The project aims at increasing the agricultural productivity and improving the living condition of the farm households via the expansion of deep well groundwater irrigated agriculture based on state-community managed approach. Accordingly, since the establishment of "Golgol Raya Development Project", hundreds of deep wells have drilled (see **Error! Reference source not found.**) and a few of them installed with modern pressurized (drip and sprinkler) infrastructures.

Figure 2: Groundwater irrigation potential, rain-gauge stations, and borehole of Raya Valley



Source: Adapted from Fenta, et al., (2015)

Use of groundwater is rapidly increasing since recently to bring numerous socioeconomic benefits to smallholder farmers by growing more crops and minimize the impact of rainfall variability and seasonal drought. In the study area, there are no perennial rivers and streams except some springs at the Western edge and runoff from these springs disappears in the central part of the valley. This situation has made groundwater the primary resource irrigation in the valley. This does not mean that the groundwater resource is uniform throughout the valley (see **Error! Reference source not found.Error! Reference source not found.**).

Agro-ecologically, the valley is one of the most productive farming areas in the region in terms of crops and livestock. Raya valley is characterized by a bimodal rainfall pattern with a short rainy season 'Belg' (low rainy season) from February to March and a long rainy season 'Kiremt' (high rainy season) from June to September with a peak in August. The spatial distribution of rainfall is mainly governed by variation in altitude. Soils are mostly loam and silt loam to clay loam texture with better water holding capacity. The soils are deep and moderately deep and are suitable for irrigation in particular and for agriculture in general. Diversified variation in agro-climatic zones, soil types and socioeconomic conditions of the farming communities, has contributed to the evolution of different cropping practices in the region in general and study area in particular. Teff[1] and sorghum are being relatively drought resistant the dominant crops both in Raya Alamata and Azebo woredas.

This paper mainly addressed the following questions: What are the benefits of the groundwater irrigation in the study area? What are the main institutional arrangements and their roles in governing the groundwater irrigation schemes for sustainability? For this study, both quantitative and qualitative primary data collected using semi-structured interviews, key informant interview with peoples who well informed about the policy and implementation, and focus group discussions with people at both district/woreda and local/community levels with groundwater irrigation beneficiary farm households to grasp the necessary information to the study. The data collected have systematically been analysed using a mixed method approaches (both qualitative and quantitative methods) to incorporate in more illustrative forms.

3. Demographic Characteristics of Sample Households

Household characteristics such as age, sex, education, wealth status, family size and gender may affect a households' decision to adopt irrigation and other modern agricultural technologies. Households with more educated members may have greater access to non-farm income and are able to finance the purchase of agricultural technologies. Farmers who have formal education are likely to more informing about the benefits of modern agricultural technologies and may have a greater ability to use these modern technologies (Pende & Gebremedhin, 2007; Kassie, et al., 2011). For the adoption of these modern agricultural technologies personal attitude of the farmers or their socio-economic characteristics, such as wealth, landholding, education, age and the characteristics of the technologies are a few factors among others vis-à-vis the agro-ecological context. In addition, more attention should be paid to the complexity and diversity of farmer's physical, economic, and social environment while more recently attention has been shifting towards a focus on farming systems.

Based on the survey data, from (N=226) the average age of sample household heads was 40.5 years, while the range was between 24 and 68 years. Average family size was about 5.13, which is slightly above the regional and the national average for the rural households. The survey also indicated the average active labour force in the household was about 3.02 and the average dependent family members in the household was about 2.09 (see Table 1). Therefore, the average dependency ratio of the household in the study area was about 0.692. Regarding educational situation of the respondents it was found that approximately 39.82% of the households were illiterate (did not read and write), while 4.42% of the respondents could read and write but without having a formal education (i.e. religious education). About 31.86% of the respondents had a primary school education and nearly 23.5% of respondents were received access to secondary school. In total, about 59.18% of sample households can read and write with about 54% of them have formal education.

Table 1: Demographic characteristic of sample households

Demographic characteristics			**Educational situation**		
Indictors (N=226)	**Mean**	**Std. Dev.**	**Level of education**	**Freq.**	**%**
Family size	5.13	2.17	Illiterate	90	39.82
Male	2.65	1.33	Religious	10	4.42
Female	2.53	1.39	Primary	72	31.86
Adult members of the household	3.02	1.63	Secondary	35	15.49
dependent members of the household	2.09	1.54	Above secondary	19	8.41
Dependency ratio	0 .69	0.57	Total	226	100

Source: Own sample survey (2014)

Having formal education by the farm households may be important to increase agricultural production and productivity through adopting agricultural technologies easily. Accordingly, younger farm households may be more educated or be more open to trying out new technologies than the old and illiterate farm households. This indicates age and education have increased the awareness about the relevant of modern agricultural activity in general. Adopting improved agricultural technologies therefore have greatest effect for improving productivity and production of the smallholder farm households. Smallholder farmers are more efficient in the allocation and use of resources than the large-scale commercial farmers in developing countries, like Ethiopia.

[1] Teff is an endogenous a staple food crop in Ethiopia; i.e. Teff is a cereal, used to make 'injera', a pancake that is the basis of traditional food.

4. Farm Size and Land Holding Arrangement of the Farm Households

In an agrarian society like Ethiopia, ownership of agricultural land as well as ownership of livestock referred to as curial productive assets. These assets are a prerequisite in the productive activities for agricultural production. Similar to other parts of rural Ethiopia, farmers in the study area can access agricultural land through land distribution, family inheritance, fixed rent and sharecropping mechanisms. Both fixed rent and sharecropped are indicating temporary ownership of agricultural land holding by the farm households.We assume that, irrigated plots in the study area are more or less homogeneous in terms of soil type and quality with slight differences. The Raya valley irrigation project has found in lowland areas with upstream catchments, which the plain area is very suitable for farming practices.

Accordingly, about 85.84% of the sample households have accessed land through the land distribution system and about 12.83% of them have inherited from their families/relatives. On the other hand, about 41.59% and 19.91% of the sample households have sharecropping and leased in agricultural land in the form of fixed rent respectively as an additional agricultural land holding arrangements/ mechanism. This implies a household can have access to agricultural land (to be irrigated or non-irrigated) through a combination of land distribution, sharecropping and fixed rent arrangements. Sharecropping is a common practice and long-aged practice in the study area, which implies the landholder will share from the final output. It is customary for the landholder to choose sharecropping contracts with a wealthier and less liquidity constraint tenant in most cases male-headed households who is likely to invest in productivity and production enhancing inputs.

Sharecropping has observed as occurring between households with an excess ratio of land to labour or land to draft power, and those who are land deficit relative to their labour and draft power endowment. For instance, 54.42% of the sample households sharecropping-in irrigated plots from other farm households and 6.2% of the sample households also sharecropped out their irrigated plots to the other farm households (see **Error! Reference source not found.**). Sharecropping arrangement in the community has not based on dominancy and dependency relations between tenants and landowners rather it undertaken to balance resources. There are two type of sharecropping arrangements/contracts in the study area such as pure sharecropping (output sharing for rain-fed agriculture) and cost sharing (input and output sharing for groundwater-irrigated plot). The duration of sharecropping and fixed rent is depend on the agreement of both parties; of course, for fixed rent arrangement there is a maximum limit set by government, five years. Why because as per of the constitution of the country land is a government-public ownership and farmers have given unlimited use rights. Farmers have the right to bequeath, the right to obtain compensation for their investment in the land in case they lose the land, and the right to lease their land for a limited period. But land sale is illegal and not allowed to use as collateral for credit as per the constitution of the country.

The study indicates the average household own land size holding (both irrigated and rain-fed) is about 4.1tsimad (about 1.025 hectare); i.e. one hectare is equal to four tsimad or one tsimad is equal to a quarter of hectare. When incorporated both fixed rent and sharecropped in (i.e. temporary agricultural land holding arrangements) the average land size holding per household increasing to about 6.1tsimad (1.525 hectare). Average own plot size of the household with access to groundwater irrigation is about 1.49tsimad (0.372 hectare). When incorporating both sharecropped and rented in into own plot size the holding of plot with access to groundwater irrigation is increasing to about 2.15tsimad (0.538 hectare).

Farm households who do not have own land, particularly in the groundwater irrigation project, can temporarily owned land either in fixed rent or sharecropping mechanism from these farm households cannot have the capacity to cultivate themselves due to different constraints. In addition, households who have their own plot also can temporarily owned additional plot either fixed rent or sharecropping to diversified and intensified their household income via cultivated more plots. There were fewer people rented out (leasing out) their irrigated plot and landowners preferred to cultivate their own land rather than lease it out. A few households, particularly women headed households and elders as well as the poor one, who own irrigated plots tended to rent out their land mainly due to lack of physical and financial capacities to cultivate it by themselves. The participants also noted that many better off farmers including landless farmers, extension workers and town dwellers from Alamata and Mohoni have higher demand to rent-in irrigated plots. This pushed up the value of the land higher and higher from time to time.

Table 2: Cultivated land arrangement and average holding size (in tsimad) of the respondents

Plot arrangement systems	Obs.	%	Mean	Std. Dev.
Owned irrigated land	194	85.84	1.49	1.24
Owned rain-fed land	196	86.73	2.52	2.1
Sharecropped-in irrigated	123	54.42	0.8	0.99
Sharecropped-in rain-fed	128	56.64	2.81	2.71
Rented in irrigated	70	30.97	1.5	1.05
Rented in rain-fed	62	27.43	0.69	1.47
Total size irrigated	213	94.25	2.15	1.42
Total size rain fed	216	95.58	3.8	3.39
Sharecropped-out irrigated	14	6.2	0.66	0.62
Sharecropped-out rain-fed	21	9.29	0.96	1.24
Rented out irrigated	10	4.42	0.88	0.86
Rented out rain-fed	5	2.21	0.2	0.45
Total size irrigated	19	8.41	1.29	1.31
Total size rain-fed	21	9.29	0.64	1.01

Source: Own sample survey (2014)

5. Agricultural input Utilization of Groundwater Irrigation Beneficiaries

5.1. Access to agricultural extension service of the farm households

Ethiopia, one of the Sub-Saharan Africa countries with the greatest state involvement in the agriculture sector and has made the highest level of public investment in the sector. The state affects the farmer's activities directly at the field level in four main ways. "First, farmers' cooperatives are responsible for supplying agricultural inputs (fertilisers, selected seeds, loans). Second, rural credit institution mainly state owned provide rural loans to the farm households. Third, participation in collective work, known as 'communal work', 'development work' or 'social work' is compulsory to local development programmes; to build rural infrastructure and improve the agricultural environment. Fourth, largely interlocked with the former, is the agricultural extension programme, probably the largest in sub-Saharan Africa" (Davis, et al., 2010:14). The state has been remarkably efficient in building rural infrastructure (including irrigation) needed to enable the farmers to meet a growing demand, notably in cash crops. The current survey also noted increased their productivity and production (notably cash crops have done so with considerable public support, which is one of the main aims of the agricultural extension programme.

Access to extension and training services expected to improve farmers' knowledge and skills of resource management and efficient use of resources. Such access can reduce farmers' risk averseness that causes anxiety towards technology adoption, because poor farmers are quick to adopt once they see evidences of the technology's ability to generate higher income and increased yields. Evidence from Egyptian small desert farmers, for instance, shows that witnessing the success of nearby large farmers, small farmers had persuaded to adopt drip irrigation (Mourshed, 1995). It is widely recognized that agricultural extension services play a considerable role in motivating and increasing awareness of farmers towards the adoption of improved agricultural technologies including groundwater irrigation. The introduction of HYV seed (crops and vegetables), efficient use of irrigation water and proper use of agricultural inputs are significant factors for improving crop production and productivity (Bhattarai, et al., 2002). Therefore, in order to improve irrigated agricultural production and productivity an emphasis has placed on increasing the diffusion of modern agricultural inputs in efficient manner and increasing the awareness of the farm households.

Public support programme for modern agricultural technology adoption in the rural sector commonly known as agricultural extension service. For this study, extension service defined as a system and set of functions that may induce voluntary change in the rural agriculture sector. The system dominated by public and semi-public agents and the functions could be transferred of knowledge, information, managerial capacity and diffusion of modern agricultural inputs. The public sector is the single most important player in Ethiopia's agricultural development programme, especially in terms of input supply via its agricultural extension programme at the community level for smallholder farmers. Overall, the aim of the extension service is to provide practical (technical) education to the farmers and foster the flow of information between farmers and stakeholders (i.e. input providers).

Therefore, agricultural extension programmes can have varied effects depending on what technologies they promote and the level of adoption by the farmers. In the study area, as elsewhere in other parts of the region, the agricultural extension programme has strongly promoted increased use of external inputs such as fertiliser, improved seeds, and other chemicals. To boost the benefit of irrigation, the use of modern agricultural inputs with modern farming system is very crucial. In this regard, the survey showed that during 2005/6 production year, about 52% sample households received overall government extension services and support (training and technical support) related to crop and horticultural production (Tesfay, 2008). Further during the production year 2009/10 about 85% of sample households received government extension service and support in the study area (Yirga, 2011). The current study indicates in 2013/2014 production year about 92.04% of the total sample households had received an overall government agricultural extension services and supports. This indicates how the extension service is reachable to all farm households and the awareness of the farm household also changed through time related to benefit of the services.

In villages where there is modern groundwater irrigation, one extra extension agent (with irrigation profession) appointed to follow-up the day-to-day activity of the beneficiaries in addition to the other three extension agents per village throughout the region. Some of the basic extension services that provide by the development agents to the farm household provided in (**Error! Reference source not found.**). Even though the government give due attention to the extension services, the information received from the beneficiary farm households revealed that there are some limitation related to receiving appropriate extension service/support from the development agents. For instance, the survey result indicates the farm households shared their opinion as 60.18% respond the extension service is very helpful, 33.19% moderately helpful and 6.64% respond as not helpful.

Some of the limitations related to the extension service are; extension workers have lack of knowledge in key areas such as intensifying or diversifying farming systems, agricultural marketing-oriented and other communication and soft skills such as how to organize farmers based on their interest. This indicates extension workers lack practical skills due to lack of exposures on-farm experience and narrower subject matter more of technically oriented training. The extension work in the study area has not been more participatory little consideration has given to farmers' experiences and knowledge. The extension workers' pay attention for the diffusion of agricultural technologies (in top-down approach) rather than critically follow up for the actual implementation of these technologies by farmers to augment their productivity and production. Further, they have low job satisfaction and most of them seek either alternative career opportunities or changing their profession.

Table 3: Basic extension services provided to the beneficiary farm households

Services/advices	Obs.	%
Fertilizer utilization/application	203	89.82
Farmland preparation	11	4.87
Irrigation resource utilization and management	150	66.37
Postharvest handling and output marketing issue	18	7.97
New seed verities application/utilization	131	57.97
Credit and saving services	45	19.91
Pest and insect infestation management	109	48.23
Improved animal production	47	20.8

Source: Own sample survey (2014)

5.2. Fertilizer and High Yield Variety seeds utilization

The development and expansion of irrigation encourages to the user farmers to make investments on modern agricultural inputs particularly in fertilizer, high yield variety seeds and market oriented cash crops to maximize their benefit from the irrigation infrastructure. Experiences from developed countries assured a sustained use of improved agricultural technologies increased agricultural production and productivity (FAO, 2002). Due to this government have given due attention for the supply and distribution of modern agricultural inputs to smallholder farmers. Smallholder farmers tended to adopt simple technologies first before moving on to complex ones, while cheaper technologies may be adopted before the more expensive ones. Adequate and concrete information regarding the existence of new agricultural technologies is of course a prerequisite for adoption of these technologies because smallholder farmers are risk averse by nature. The information can be diffused via different sources such as extension agents, neighbourhood farmers, television, radio, and local newspapers, which play a central role in access information to the farm households as well as changing the awareness of the farmers. Information is crucial for farmers to assess the suitability of the technology for their farming system and to understand the potential risks associated with the use of the technologies. This does not mean that, accessing and searching of such information cannot be simple and easy particularly for uneducated and poor smallholder farmers in developing countries, like Ethiopia.

One of the expected changes because of improved access to irrigation is increase in use of yield enhancing agricultural technologies (mainly fertilizer and improved vegetable seeds). Tesfay (2008) reported that, only 19% of groundwater irrigation users in the study area were used fertilizer and all of them used improved seeds such as onion and tomato in the production year of 2005/06. The current survey indicates about 90% of groundwater irrigation users used chemical fertilizer and all of the users used improved seed (such as onion, tomato, maize and teff) in their irrigated plots in the production year of 2013/14. Thus, there is an improvement in fertilizer and other inputs utilization by groundwater user farmers. This indicates households with access to irrigation are significantly more likely to use fertilizer than households without access to irrigation and households use significantly higher amounts of fertilizer on irrigated plots than on rain-fed plots (Gebregziabher, 2008). The larger volumes of improved seeds used in irrigated agriculture in the study area were tomato and onion though sometimes farmers had faced difficulties to get quality vegetable seed varieties. Farmers raised some basic problems in relation to imbalance between supply and demand (high demand but less supply), less quality of seeds, high price of seeds, delayed in supply (unavailable on time). As a result some of the farm households' bought these inputs from the private traders to solve the problems of deficiency and delays and exposed for high purchasing cost.

5.3. Access to credit and training

As irrigated agriculture is input intensive by nature (both labour and other inputs) irrigation may aggravate the liquidity constraints of poor farm households to access main agricultural inputs. Therefore, access to credit reduces problems of liquidity and enhances the use of agricultural inputs. This indicates the contribution of rural credit institutions is greatly important in providing credit to create financial capital alternatives to the farm households to investment on their irrigated agricultural activities. Therefore, access to credit is crucial to boost investments in agricultural sector to increase productivity or to diversify the economic activities of rural farm households. Credit predominantly used for the purchase of livestock, farm inputs such as fertilizer, seed and pesticides and in some case for the construction of house.

Dedebit Credit and Saving Institution (DECSI) has provided institutional credit for buying farm inputs (such as seed, fertilizer, chemicals, and oxen) for households in the study area, in Tigray regional state. Further, Farmers' Cooperative Associations also provides institutional credit to the farm households both in kind (i.e. agricultural inputs and other farm equipment) and in cash. In addition to these formal credit institutions, there are a few informal credit source arrangements at the local level in the study area. Some of them sources are relatives, friends, neighborhoods, local moneylenders, local community insurance (Iddir) and rotating savings and credit associations (Iqub). However, the survey result indicated only 26.55% of the sample households had borrowed money from different credit sources during the year 2013/14. Some of the reasons that many of the farm household did not take credit are first, due to high rate interest of the lending institutions (for instance, for DECSI lending interest rate is about 18%). Second, religious restriction/impact especially Muslim farm households have not allowed taking credit with interest. Third, borrowers are required to take collective liability for loans, as no material collateral is required and many of the respondents confirmed that they do not want to take collective liability. Lastly, many of the respondents confirmed have not financial problem to purchase agricultural inputs since they started using irrigation.

Training is an important tool for the farm households in order to understand the role and benefit of the agricultural inputs to improve their productivity and production. The study shows that about 66.81% of farm households respond that they received training at least one time since they start to practice groundwater irrigation. Main training components given to the farm households were: agricultural extension (such as crop and vegetable production, fertilizer utilization, compost preparation and modern groundwater irrigation utilization); and natural resource management (such as watershed management like terracing and agro-forestry). Many of the trainings delivered by the Agricultural and Rural Development Office and Farmers' Cooperative Associations Agency and some of them also delivered by local and international NGOs. As a result, knowledge on seedbed preparation, seedling production, optimum transplanting time, and stage of seedling growth, line planting and spacing, crop rotation, watering frequency, disease and pest control, harvesting stage and storage techniques have introduced in the study area.

In general, smallholder farmers require the necessary knowledge and information to use modern agricultural technologies. Sources of information and learning can encompass training, external sources (such as extension agents, neighbourhood farmers, television, radio and local newspapers can play a crucial role), experimentation and learning from neighbourhood farmers in the form of sharing good practices. Moreover, using these modern agricultural technologies is crucial to maximize production and productivity of the smallholder farmers. Accessing these resources will need well-functioning factor markets, which can be a constraint to the rural areas due to input demand is seasonal and small-scale. Collective purchasing of inputs, for instance, through Farmers' Cooperative Associations or Water User Associations (WUAs) groundwater irrigation users could help to address these constraints by creating economies of scale and reducing transaction costs in the study area to maximize the benefit of groundwater irrigation infrastructure in particular and rural development in general.

6. Crop Diversification/Intensification Using Groundwater Irrigation

Access to reliable irrigation has been regarded as a powerful factor which provides a greater opportunity for cropping intensity and multiple cropping/crop diversification (Shah, et al., 2003). Before introduced groundwater irrigation technology in the study area, majority of the farm households produced main staple crops such as teff, maize, sorghum and barley most commonly for consumption purpose. Vegetable and fruit cultivation were limited only to households who had access to irrigation from river diversion and micro-dams such as pond. But since recent time after the introducing groundwater irrigation scheme as one of pro-poor and pro-development Programme by government beneficiary farmers are start to produce high value (market oriented) horticultural crops such as tomato, onion, pepper and others. The information from the sample households revealed that most of the farmers produced more than one crop per production season. Vegetables appeared to provide the most intensive production system where majority of the farmers have commonly able to produce twice or more per year. The highest proportion of vegetable production in terms of the number of producers was onion and tomato respectively. As (Table 4) indicates, onion grown by 76.55% of sample households both in the first and second seasons of production periods of 2013/14 followed by tomato 33.63% of the sample households using groundwater irrigation. Furthermore, the beneficiary farm households also produced two main staple crops (maize and teff). In the same production seasons, about 70.8% and 54.42% of the sample households produced maize and teff respectively.

Table 4: Type of crops/vegetables produced and average output (Quintal/ha) in 2013/14

Crop/vegetable	First season (1)			Second season (2)			Total (1+2)	
	Obs.	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**%**
Maize	89	38.94	32.38	71	31.36	16.63	160	70.8
Teff	55	17.57	10.51	68	14.41	10.16	123	54.42
Barley	12	22	15.59	9	13.78	11.16	21	9.29
Pepper	6	73.33	46.76	2	34	19.8	8	3.54
Tomato	44	148.64	132.17	32	203.84	153.1	76	33.63
onion	81	141.66	80.40	91	158.39	90.1	172	76.55
cabbage	3	191.1	186.83	5	269.2	252.16	8	3.54
others	15	34.15	41.04	15	24.93	27.45	30	13.27

Source: Own sample survey (2014)

As (Table 4) indicates, there have been significant differences in productivity per hectare between cash and staple crops using the same agricultural technology such as groundwater irrigation and other inputs. Some of the justification given by the beneficiary farm households are first, if they cultivate the whole of their plot with onion or tomato they will expose for price volatility or in short they face marketing problem. Second, they need these staple crops for consumption and use their residues (straw) for livestock fodder, which likely lead to an increase in the number of livestock kept by the households. Third, practicing crop rotation or inter-cropping farming mechanisms will help them to sustain/maintain soil fertility of their plot. The average onion yield per hectare was estimated about 141.66 quintals in the first season and 158.39 quintals in the second season of the 2013/14. Further, the average tomato yield per hectare was about 148.64 quintals in the first season and 203.84 quintal in the second season of the same production period. On the other hand, the average maize yield per hectare was about 38.94 quintals in the first season and 31.36 quintals in the second season of the 2013/14. Furthermore, the average teff yield per hectare estimated about 17.56quintals in the first season and 14.41 quintal in the second season of the same production period.

Obviously, yield per hectare for tomato and onion was much higher than the staple crops (maize and teff) using the same inputs such as groundwater irrigation and chemical fertilizers. In effect, average income per household those who produced cash crops in a given production season was about three folds of those who produced staple (see Table 5). Overall, in terms of output and farm income producing cash crops is much preferable than producing staple crops, though the price of cash crops much lower than these staple crops. Therefore, access to reliable groundwater irrigation does positively contribute to patterns of diversification, intensification and increasing farm households' productivity per hectare and their income.

Table 5: Value for output of crops/vegetables (in ETB) in a Year 2013/14

Crop/vegetable	First season		Second season	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Maize	8208.61	6389.86	7339.58	5795.31
Teff	7719.65	6428.64	6251.28	5111.72
Barley	4838	2911.76	2466.67	1879.49
Pepper	6750	4957.32	9100	5798.28
Tomato	22473.18	28595.9	21971.72	28512.88
onion	22183.23	13915.88	27587.7	20293.4
cabbage	14666.67	8082.91	26080	7623.12
others	6561.87	5561.97	5826.67	5694.92

Source: Own sample survey (2014)

Groundwater irrigation infrastructure has positively contributed to the beneficiary farm households directly through increasing their farm income and to the non-beneficiary indirectly via creating seasonal employment opportunity. Some of the economic and social benefits, which beneficiary farm households have attained via using groundwater irrigation infrastructure, are:

- Almost many of the beneficiaries achieved food self-sufficiency and food security at household level;
- Fully employed their family labour force for their farming practices and hired additional labour force;
- Improved the income level of the household via using additional agricultural inputs and improving their farming practices;
- Improved their level of saving (asset holding) and their farming practices (i.e. adopting/practicing intensive and extensive farming) approach;
- Improving their level of consumption at the household as a result of increasing their income level;
- Better access extension, credit and training services from government and non-government institutions;
- Build new and better house, purchase additional livestock and other household assets;
- They send their children to school without any problem; including to private colleges;
- Receive better social status in the community due to improving their wealth status are some of them.

In sum, irrigation can increase the intensity and diversification of crop production by enabling production of multiple crops per production season or year and in turn increasing the return of modern agricultural inputs. Therefore, irrigation can contribute for increasing input intensity moisture availability that in turn improving productivity, total yields and farming practices.

7. Accessibility to Institutions/Organizations and Community Participation

Households with greater 'social capital', for instance, those with more social relationships, possibly through involvement in local organisations may have better access to information or timely availability of inputs, and thus able to be more productive. Involvement in agriculturally oriented organisations such as farmers' cooperatives and agricultural cadres may increase farmers' awareness about the new technologies and management practices, and in turn increase their productivity and production (Pender & Gebremedhin, 2007). Furthermore, with the existence of scarce or inadequate information and fragmented markets (both factor and output markets), social capital/networks allows and facilitates the exchange of information, enables farmers to access agricultural inputs and address their credit constraints. Being a member of in different associations reduce transaction costs and increase farmers' bargaining power, helping farmers to earn higher returns when marketing their products at a proper market with such information and bargaining power (Wollnia, et al., 2010).

Access to agricultural output and input markets, the availability of information and support organizations, including credit institutions are very critical to increase the productivity and production of the farm households. The effect of membership in farmer-based organizations such as cooperatives, Water User Associations (WUAs), and marketing organization has positively contributed for the farm households' investment decision. Farmer-based organizations can significantly reduce transaction and information costs associated with smallholder production and marketing. For instance, farmers' cooperative associations can collect information about production technologies and consumer preferences and provide it to their members in the form of extension visits and demonstration sessions. Therefore, cooperative membership would be significant to the farm households to benefit from the services that provided by the cooperative associations.

As a result, the sample households from the study area confirmed that almost all adult members are member of different local organizations or institutions (both formal and informal associations) at their community (see Table 6). Being a member of both formal and local institutions/organizations, the farm households augment their social and economic benefits via strengthening their interaction within the community. These institutions and organizations are very helpful to the community to exchange political, economic, and social aspects within the community or across it. In other words, farmers empowering by getting them organized into formal and informal groups (social capital) based on common interests. For instance, informal organizations at the community level include funeral groups or community insurance (Idir), labour sharing groups, and savings and loan type groups like rotating saving (Iqub) played crucial role in social interaction and used as a mechanism of information sharing in their day-to-day activity. These institutions and organizations are used as a point of interaction between the state and society to accelerate rural development transformation. For instance, the first four associations are semi-state institutions (see Table 6) that help to mobilize the community to participate in their local development programmes. Communities' participation in collective work, known as 'communal work', 'development work' is essential to local development programmes. Accordingly, the community have actively participated in local development programmes in different aspects; some of the local development activities that the community participating are:

- Building irrigation infrastructure such as in water diversion structures for spate irrigation and other small-scale irrigation practices;
- In building and maintenance of rural road programmes such URRAP (Universal Rural Road Access Programme, which started since 2010/11) at village level;
- In compost preparation (composting) to boost soil fertility and then productivity and production;

- Soil and water conservation activities such as stone trenches or terracing or planting trees (afforestation) to protect their environment i.e. broadly in watershed management activity, which are crucial to improve the agricultural environment;
- Shallow well ('Ella' or 'Kurie') digging for both livestock and micro-irrigation purpose;
- Building and fencing of their local institutions such as school, health centre and post, water institutions, FTC and other local institutions.

Table 6: Household's membership or networks at the community level

Community association/organization	Households' response				Mean membership (in years)
	Yes	%	No	%	
Farmer's association	122	53.98	104	46.02	9.13
Women's association	167	73.89	59	26.11	8.2
Youth association	118	52.21	108	47.79	5.93
Farmers' cooperative association	131	57.96	95	42.04	6.23
Iddir/funeral &wedding services association	187	82.74	39	17.26	10.54
Iqub/rotating savings group	78	34.51	148	65.49	5.37
Feast days (Mahber) association	113	50	113	50	10.53
Exchange/Sharing draft power	77	34.07	149	65.93	10.33
Theft prevention group	124	54.87	102	45.13	6.7
Community risk prevention pool	99	43.81	127	56.19	3.72

Source: own sample survey (2014)

Furthermore, as (

Table 7) indicates the communities have an access for the following basic formal institutions to get necessary services such as village administration centre, heath post, elementary school, grain mill, FTCs, village farmers' cooperative centre, veterinary centre, social/customary courts (Mahberawi firdbiet in Amharic), which accessed on average within the radius of 3-5kms and ranges from 0.5-15km. In addition, the community have access of woreda market, and health centres, district hospital, and secondary schools, woreda court (woreda firdbiet in Amharic) and other woreda government institutions on average within the radius of 6-15kms; ranges from 2-30kms. In relation to accessibility to rural roads, the survey revealed that all sample households have access to all weather roads on average within half an hour walking distance for a single trip to access all institutions.

Table 7: Accessibility of formal institutions by the community of the Raya Valley

Institutions	Distance (in Km)		Time take (in Minutes)	
	Mean	Std. Dev.	Mean	Std. Dev.
Nearest health centre (N=223)	3.95	4.36	37.77	39
Nearest health post (216)	2.78	2.77	25.2	18.65
Nearest elementary school (N=222)	1.64	1.46	13.61	10.14
Nearest grain mill (Metihan) (N=222)	1.52	1.47	13.75	13.38
Local social/customary courts court (213)	1.93	2.1	17.65	19.14
Farmers Training Centres (N=222)	1.68	1.42	15.95	14
Village cooperative centre (N=220)	1.93	2.24	16	15
Nearest Veterinary centre (N=223)	3.28	3.69	31.84	37.23
Nearest local market (N=160)	5.92	6.51	59.88	67.39
Nearest secondary school (N=225)	6.71	5.59	65.44	54.57
Woreda market (N=225)	8.31	7.71	78.79	46.47
Zonal/district hospital (N=224)	15.93	11.39	157.98	113.84
Woreda court (N=202)	8.65	9.12	81.22	46.37

Source: Own sample survey (2014)

For instance, access to market can influence farmers' decision making in various ways, such as availability or accessibility of agricultural inputs, the use of input and out markets, access to information and support institutions/organizations, for instance, credit institutions and extension services (Pender & Gebremedhin, 2007; Wollnia, et al., 2010). Yet both input and output markets are highly fragmented where informal brokers set market prices, usually against the interest of farmers. The problem is profoundly difficult during harvest season when in most cases farmers cultivate high value but perishable cash crops. Obviously, lack of better market access directly affected farmers from obtaining a better price for their produce. This leads to reduce the motivation of the farm households to make further investment on the groundwater irrigation. As a result, some of the farmers either they rent out or sharecropped out their irrigated farmland to minimize the expected and actual risks via cultivating their plot themselves.

About 68.58% sample households in Raya valley complain about market problem and lack of fair prices for their output, particularly for cash crops (onion and tomato). Furthermore, lack of alternative market outlet or information and lack of easy access to nearby efficient market are also the main problems explained by the sample respondents. For instance, price volatility during the harvesting season is remaining the main problem in the study area. About 66.37% of the sample respondents confirmed that price volatility is their main problem followed by lack of market information 28.31% and far distance to the regional market and high transport costs 12.83%. The main cause for the price volatility especially in cash crops is many of the famers in the study area produce the same/identical product (for instance, onion and tomato) at a given production season. This all indicates the farm households and their families have access basic institutions, which are important to facilitate their political, economic, cultural, and social development. To get the necessary services from these institutions in a sustainable manner the farm households have kept them as their own property. The farm households in the study area have relatively strong interaction with both these state and non-state institution related to their agricultural activities and other social issues.

8. WUAs and Management Issues of Groundwater Irrigation schemes

There are different management styles associated with government-led irrigation schemes. Some of these management styles are the agency/department managed, farmer-managed or the community managed schemes and public-beneficiary managed. Most management institutions of government-led irrigation schemes of large or medium scale are public institutions with subsidy from the government while small-scale systems mostly manage by the communities through WUAs. The information from the survey revealed that all of the groundwater irrigation schemes managed by the beneficiary farm households via their WUAs (user cooperative associations). The respondent explained, after installing the necessary groundwater irrigation technologies training had given for all beneficiaries regarding the benefits of the new irrigation technology related to how to operate and how to get provision of technical support from responsible institutions. In Raya valley the groundwater irrigation beneficiaries practiced, more of enterprise-oriented model. Each of the wells operational under WUAs (or water user cooperative association) with on average eleven committee members put in place to manage the overall groundwater irrigation system. This indicates efforts have made to involve farmers progressively in various aspects of small-scale irrigation systems management aspects related to water distribution as well as operation and maintenance to improve the performance of irrigated agriculture.

Based on the information received from the respondents', above 89% of the respondents confirmed that the irrigation scheme administrates by WUAs and about 95% of the farm households participated in the general meeting of the association to elect their committee/leaders. Each of the groundwater irrigation schemes' user associations has their own rules and regulations (by-laws). The by-laws are the primary source of internal rules and regulations (the constitutional rules of each WUA) that regulate the WUA's activities. Based on their by-laws the respective WUAs have a general assembly in which all members of the irrigation beneficiaries are assembled to discuss the highest-level issues, election of committee members, and decision on the amount of fee for irrigation power use per plot, etc. The executive committees have the following major responsibilities. Take care of physical structures of the irrigation scheme at the field, monitoring pump operation and facilitation of maintenance when necessary, supervising the normal water distribution and execute other related issues as specified in the document and communicate with the Developmental Agents, Woreda Agricultural Office, Water Resource Office and Farmers' Cooperation Agency in relation to the condition of the scheme.

Table 8: Performance evaluation of WUA/cooperative committee by the beneficiaries

Indicators/Activities	Evaluation the role of the committee					
	Poor	**%**	**Good**	**%**	**V. Good**	**%**
Leadership fairness and equity	15	6.64	156	69.03	55	24.34
Resource mobilization and distribution	21	9.29	138	61.06	67	29.65
Infrastructure maintenance and operation	34	15.04	145	64.16	47	20.80
Control irrigation equipment	30	13.27	149	65.93	47	20.80
Accountability &responsibility	20	8.85	153	67.70	53	23.45

Source: Own sample survey (2014)

WUAs are public-interest associations and have legal status they established on the initiative of government in order to assured the sustainability and fair distribution of the water resource and to minimize the operational and maintenance of the schemes/infrastructure (Aw & Diemer, 2005). In line to this in the study area the main justification of the transfer of irrigation infrastructure to users is to minimize government expenditure and to institutionalize irrigation cost recovery (such as operation and maintenance) by water users. It generally expected also that transfer of irrigation management would contribute to improve the performance and increasing the sustainability of irrigation systems. Some of the characteristic and institutional frameworks of WUAs in the study area as elsewhere are:

Characteristics of WUAs:

- WUAs are public law organizations and their mandate is of a public interest nature;
- Membership is compulsory and linked to the land plot within the service area; every person who, based on a land use right, uses land located within the service area of WUA is a member of the association. Compulsory membership is essential to ensure WUA sustainability;
- WUAs operate on a non-profit/non-commercial basis but they will nevertheless provide services to their members, such as the provision of irrigation water to its members for agricultural purpose;
- They very often use public infrastructure irrigation scheme, i.e. infrastructures built with public money and owned by the government;
- WUAs are self-managed organizations governed by their members, but due to the public interest nature of their tasks are subject to some form of supervision by the government;
- The tasks of WUAs are strictly limited to management, operation and maintenance of an irrigation system and watershed management for the sustainability of the irrigation resources;
- The state has the right (and the duty) to ensure that WUAs operate lawfully and correctly in the public interest because the public made the investment with the objective to ensure the benefit of the farm households.

Institutional frameworks of WUAs:

- The WUAs have granted a water-use right after the infrastructure completed by government;
- Beneficiary farmers contribute to the cost of operation and maintenance or repairs works (in the form of money, labour and/or materials) and pay electric fee based on plot size or per hour in some furrow irrigation schemes;
- The WAUs have their own by-laws, which approved by the 'general assembly' of an association, which is the supreme decision making body of an association. The by-laws define the roles, tasks, rights, and responsibilities of WUAs, the committees and their members. The by-laws of the WUAs in the groundwater irrigation schemes developed via the support of the woreda Farmers' Cooperative Association Agency;
- WUAs leaders, 'management committees', that consists of minimum five and maximum eleven members elected democratically by the general assembly to oversee and supervise the activities of an association; further there are different sub-committees under the management committee;
- The committee regularly/formally meets on a monthly basis to discuss about irrigation and farming related issues in their scheme; however, that may hold extraordinary meetings at any time as may be necessary;
- There is annual general assembly to assess progress and agree on a work plan for the year ahead. In addition, there are also quarterly and mid-year evaluation(gimgema in Amharic) about the performance with the beneficiary or members of the association;
- WUAs have legal status enter into contracts and to enforce sanctions/punishes against members who break the rules;
- The closer involvement of WUAs has resulted in increased accountability, transparency and responsibility because of developed a sense of ownership in irrigation infrastructure;
- Reducing government expenditure related to operation and maintenance, and reorientation of institutional arrangements;
- WUAs tend to responsible for providing services related to water distribution and the provision of agricultural inputs such as fertilizer and other inputs to their members via communicating with the Farmers' Cooperative Association Agency that the sole supplier of agricultural inputs in the study area;
- Enhanced communication between users and the extension agents, Woreda Water Resource and Agricultural and Rural Development Offices, Cooperative Agency and other stakeholders;

Roles related to WUAs can sort out into three major categories: governance (social management) related to general assembly, operation and maintenance, and management related to management committee. Some of the management tools of WUAs to plan, implement, and monitor their activities, water distribution plans, and budgets related to operation and maintenance, electricity charge fees and other financial aspects. To be effective in providing livelihood benefits, groundwater irrigation schemes need a strong and inclusive institutional component to address all problems that farm households' encountered. WUAs, for instance, tend to planned multiple uses in addition to groundwater irrigation distribution and electricity fee collection. WUAs should represent the user farmers in a command area democratically; have legal status to enter into contracts and the necessary authority to manage an irrigation system (partial or whole); operate and maintain irrigation infrastructure; and have administrative and financial autonomy. The management structure of a WUA is similar across all the irrigation schemes in the project area. Designing institutions for governing irrigation systems is challenging and a bit complex issue. It requires skills in understanding how rules produce incentives and outcomes when combined with specific physical, economic and cultural environments.

Irrigation institutions have to be effective to promote and manage irrigation schemes to be productive, efficient, and sustainable. Effective institutions are required at all levels from the farm level to the national level for the sustainability of the resource. These institutions are responsible for ensuring irrigation productivity and efficiency, planning of irrigation development, managing of impacts due to irrigation development, formulating and implementing policy directives and funding towards sustainable irrigation development and management. The historical bias toward infrastructure investment that neglect ensuring effective institutions is one cause of poor irrigation performance and sustainability (Faurès, et al., 2007). Institutional arrangements have failed due to insufficient resources (human and capital), lack of political support, lack of proper involvement of water users, lack of capacity building and low community awareness about the benefit of the institutions related to their actual livelihoods.

In addition to the specific scheme management, community-based watershed management (through soil and water conservation activities such as gully reclamation to reclaim eroded areas and gullies) would be a significant factor to achieve the aim of making agriculture the driving force of economic development. This watershed management programme is indispensable to increase the recharge of groundwater resource, streams and realize environmental rehabilitation, which increases the aesthetic value of the ecology in general and improving the agricultural environment in particular. Given, the current favourable rural development policy framework and government's aim to make agriculture the driver of economic development, community-based watershed management offers a promising solution to increase the irrigated area across the country. Some of the opportunities derived from practicing watershed management programme are:

- Reduce farmers' dependency on rain-fed subsistence agriculture via using different water harvesting techniques for irrigation purpose;
- Protect soil erosion and land degradation through addressing flooding and sedimentation;
- Tackle water shortages and moisture stress via consolidating soil and water conservation practices;
- Separate/enclose grazing land and fodder crops for livestock;
- Boost the community's participation in environmental protection and water resource management.

In general, failure or sub-optimal operation of small-scale irrigation schemes is related to the success or failure of both structural/infrastructural (hardware) and management (institutional) factors. Hence, the importance of integrating watershed management with irrigation development is crucial to sustain irrigated agriculture at household. This implies better watershed management at community level can save excessive water that could be used either for the expansion of irrigation or ecosystem functions. In other words, poor irrigation water management practices, low level of skills of farmers and lack of support services to access improved agricultural inputs and extension services constrained productivity of the schemes. Therefore, integration of irrigation development with proper watershed management practices is crucial for sustainable irrigation water utilization in the study area.

9. Discussion and Conclusions

Ethiopia has set ambitious goals for economic development with a priority given to agriculture (smallholder agriculture) based industrialization under the long-term and comprehensive ADLI development strategy. The development of irrigated agriculture is one of the main pro-poor and pro-rural development programmes that performed via significant public investment and intensive involvement of the community in the form of public development work. The developmental state has focused on enhancing productivity and production of smallholder farmers, strengthening factor and output markets, expanding the amount of land under irrigation, and reducing the number of food insecure households as well as poverty.

Development of irrigation infrastructure has both positive and negative impacts subject to efficient and sustainable use of the resource. Accordingly, the development of irrigated agriculture if the resource properly utilized and managed, it has contributed multi-directional positive benefits to the farm households and economic development of the country. Equally, irrigation development also has negative consequences (i.e. environmental effects and social instability) if the resource is not managed in a sustainable manner and use inefficient manner (Awulachew, et al., 2007; Dinka, et al., 2014). The extensive environmental conservation activities undertaken via the public work programme helps to rehabilitate the degraded environment, and support revival of dried rivers and streams and recharge groundwater resources for irrigation purpose.

The linkages between government policies (such as investment in irrigation infrastructure) and households' well-being have both direct and indirect relationship. The direct linkages operate through households' production and consumption behaviour, while the indirect effect may cover different dimensions, both at household or beyond the household level. Public investment in irrigation improves agricultural productivity and has a positive impact on household income diversification and poverty reduction. Reliable and adequate irrigation scheme increases employment opportunities, which has a considerable impact on poverty and inequality reduction (Kumar, 2003; Hussain & Hanjra, 2004). For instance, Kumar (2003) stated that irrigated agriculture has significantly increased India's food production and created grain surpluses. Similarly, Hussain &

Hanjra (2004) showed that access to irrigation enables farmers to adopt new technologies that lead to higher productivity and increased household income. It is possible that via boosting investments in irrigation resulted in lowering output prices through increasing supply, which has positive effect on the well-being of the urban consumers.

Reliable irrigation scheme leads to crop diversification towards high valued commercial crops or horticultural crops in addition to producing staple food crops. It improves the productivity of land and agricultural labour leading to high household income and food security. Income of the farm households can augment by improving the production efficiency of irrigated agriculture coupled with using modern agricultural inputs and improved farming system. Yet both output and input markets are highly fragmented where informal brokers exercise excessive power to set market prices, usually against the interest of farmers. This implies marketing situation put farmers' bargaining power on prices lower and mostly they have to accept what the buyers/traders offers. The problem would be serious or exaggerated during harvest season when in most cases; farmers cultivate high value but perishable cash crops.

In the study area, smallholder farmers produce and supply their cash crops in a local marketing with incomplete market (both actual and predicted market price) information and low bargaining power on price of their output. The inability to secure output market has discouraged the investment perception of the beneficiary farm households and then affects the productivity capacity of the farm land. Currently, marketing output done on individual basis and the prices of these cash crops fall significantly at harvest time due to high supply. Addressing the issue of marketing may benefit to the beneficiary farm households via improving their farm income and then increasing their investment perception. The beneficiary farm households can easily cover their annual operational cost with less pressure on their asset and increasing their asset holding. Market inefficiencies negatively affect farmers' decision-making and access to modern agricultural technology. Some of the problems are poorly developed supply chains, high transaction costs, lack of information about the actual and future market situations, which resulted due to uneven information and power in output and input markets.

Another challenge is frequent breakdown of motor pumps (scheme machinery) and due to lack of spare parts and technicians for repair services make difficult and take long-time to rework the scheme. For instance, in the study area when farmers faced breakdowns of motor pump, they did not get reliable supply of spare parts, and repair/maintenance services close to their residency. When farmers faced such problem, they travelled to the capital of the regional state that is 160-180km far to get spare parts and professional services for maintenance because there is no any institutions/enterprise (to be private or state) to provide such services. This exposed to the unnecessary financial and transaction costs and therefore, government must address this problem through set up institutions to deliver such services or encourage private sectors to set up such institution. Furthermore, some of the observed challenges by the farm households in the study area are high input costs (especially cost of fertilizer); pests and diseases especially for onion and tomato; in addition to marketing problems.

Regardless to these constraints, the combination of factors such as access to credit, educated household members, input supply by cooperative associations, and access to extension services have a positive effect in increasing the efficiency of irrigated farming. For instance, educated farmers relatively have greater managerial ability, better technology adopters and have better knowledge how to make efficient use of inputs and technologies. In contrast, uneducated farmers are naturally more reluctant to adopt new farming system due to their risk-averse behaviour. Improving farmers' education via expansion of adult education programme can be an appropriate policy instrument to improve the production efficiency of irrigated agricultural practice in particular and agricultural practice in general.

Irrigation has both direct and indirect effects in the economy as well as it has income and employment effects in the agro-industry and other non-farm sectors of the economy. To materialize all these benefits of irrigation, sustainability, and efficient utilization of water resource should pay a necessary attention by all stakeholders. Effective institutional arrangements are crucial for the sustainability and efficient utilization of the resource at the service point; i.e. where the irrigation infrastructure has found. However, institutional arrangements for sustainable water resources management are not an easy task and have been subject to frequent change due to different factors (Negash, 2011). Institutional arrangements for water resource development and management in Ethiopia depend on different layers. Policy makers and standard setters at federal and regional levels for large and medium-scale irrigation; and for small-scale irrigation development project respectively. Service providers at local (district) level the Office of Water Resource and Agricultural and Rural Development, and the beneficiary farm households and their organizations at community level.

In conclusion, irrigation including groundwater development programme is one of the pro-poor investments undertaken by the state in Ethiopia and such a pro-poor public investment is crucial to the farm community at grassroots level. The expansion and development of groundwater irrigation in the study area via public investment is economically worthwhile to achieve food security at household level and increase food supply into the domestic markets. It is well accepted that investment in groundwater irrigation and access to irrigation in general can play a big role in improving livelihoods the beneficiary farm households and transforming agriculture sector. Therefore, to maximize the benefit of the groundwater resource in the study area further:

First, expand groundwater irrigation across the potential area because irrigated plots holding are not uniformly accessed across the farm community in the study area where there is a potential. Second, expand rural electrification; expanding rural electrification, which would benefit the rural community (for rural transformation) as a whole and crucial to expand the groundwater irrigation infrastructure across the potential area. Third, strengthen agricultural extension services; extension services in general and irrigation extension services in particular are crucial to boost the benefit of the beneficiary farm households. The current agricultural extension service is to some extent limited and ineffective related to the quality of the service that provide. Fourth, improve both input and output markets; both input and output markets are fragmented and inefficient, because informal brokers currently exercise excessive power in setting market prices, usually against the interest of farmers. Indeed, the availability of consistent and reliable markets for their outputs and inputs are very curial to strengthen their investment in irrigated agriculture. Fifth, encourage the role of Water User Association (WUAs); strengthening the capacity WUAs to maintain the systems and foster the active participation of farmers in sustainable utilization of groundwater irrigation schemes is indispensable. To sustain the benefit of the beneficiary farm households and the infrastructure, government and other stakeholders need to encourage the existing WUAs via provision of capacity building and other technical supports to strengthen the managerial capability of the associations.

References

Aw, D., & Diemer, G. (2005). *Making a Large Irrigation Scheme Work: A Case Study from Mali.* Washington D.C: World Bank.

Awulachew, S., & Ayana, M. (2011). Performance of Irrigation: An Assessment at Different Scales in Ethiopia. *Experimental Agriculture, 47*, 57-69.

Awulachew, S., Erkossa, T., & Namara, R. (2010). *Irrigation potential in Ethiopia: Constraints and opportunities for enhancing the system; Research report.* Colombo: International Water Management Institute.

Awulachew, S., Yilma, A., Loulseged, M., Loiskandl, W., Ayana, M., & Alamirew, T. (2007). *Water Resources and Irrigation Development in Ethiopia.Working Paper 123.* Colombo, Sri Lanka: International Water Management Institute.

Bhattarai, M., Sakthivadivel, R., & Hussain, I. (2002). *Irrigation impacts on income inequality and poverty alleviation: Policy issues and options for improved management of irrigation systems.Working Paper 39.* Colombo, Sri Lanka: International Water Management Institute.

Davis, K., Swanson, B., Amudavi, D., Mekonnen, D. A., Flohrs, A., Riese, J., . . . Zerfu, E. (2010). *In-Depth Assessment of the Public Agricultural Extension System of Ethiopia and Recommendations for Improvement.* Washington, D.C: International Food Policy Research Institute (IFPRI).

FAO. (2002). *Crops and Drops: Making the Best Use of Water for Agriculture.* Rome: UNited Nations Food and Agricultural Organization. Retrieved from at http://www.fao.org/DOCREP/005/Y3918E/Y3918E00.HTM

Faurès, J., Svendsen, M., Turral, H., Berkoff, J., Bhattarai, M., Caliz, A., . . . Doukkali, M. (2007). Reinventing Irrigation. In D. Molden (Ed.), *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (pp. 353-394). London, Earthscan and Colombo: International Water Management Institute.

Fenta, A. A., Kifle, A., Gebreyohannes, T., & Hailu, G. (2015). Spatial analysis of groundwater potential using remote sensing and GIS-based multi-criteria evaluation in Raya Valley, northern Ethiopia. *Hydrogeology Journal, 23*, 195–206.

Gebregziabher, G. (2008). *Risk and Irrigation investment in a Semi-Arid Economy.* Oslo: Norwegian University of Life Science, PhD Dissertation.

Hagos, M. (2010). *Goundwater Flow Modelling assisted by GIS and RSTechniques (Raya Valley-Ethiopia).* Enschede, The Netherlands: Unpublished Master thesis Submitted to the International Institute for Geo-information Science and Earth Observation.

Hussain, I., & Hanjra, M. (2004). Irrigation and poverty alleviation: Review of the empirical evidence. *Irrigation and Drainage, 53*(1), 1-15.

Kassie, M., Shiferaw, B., & Muricho, G. (2011). Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda. *World Development, 39*(10), 1784–1795.

Kebede, S. (2010). *Groundwater in Ethiopia: Occurrence, drought proofing and technology options.* Addis Ababa: Addis Ababa University, Department of Earth Sciences.

Kumar, M. (2003). *Food security and sustainable agriculture in India: The water management challenge.Working paper 60.* Colombo: International Water Management Institute.

MoFED. (2010). *Growth and Transformation Plan (GTP), 2010/11-2014/15.* Addis Ababa: The Federal Democratic Republic of Ethiopia, Ministry of Finance and Economic Development (MoFED).

Moges, S. (2012). *Agricultural use of ground water in Ethiopia: assessment of potentials, analysis of Economics, Policies, Constraints and Opportunities.* Addis Ababa: International Water Management Institute.

Mourshed, M. (1995). *Rethinking Irrigation Technology Adoption: Lessons fro Egyptian Deseret. Working Papere No.23.* Massachusetts : Programme in Science, Technology and Society.

MoWR. (2002). *Water Sector Development Program (WSDP).* Addis Ababa: Federal Democratic Republic of Ethiopia; Ministry of Water Resources (MoWR).

MoWR. (2011). *Ethiopia: Strategic frame work for managed groundwater development.* Addis Ababa: Federal Democratic Republic of Ethiopia; Ministry of Water and Energy.

Negash, F. (2011). *Managing water for inclusive and sustainable growth in Ethiopia: key challenges and priorities.A background paper to the European Report on Development2011/2012: Confronting scarcity: Managing water, energy and land for inclusive and sustainable growth.* Addis Ababa: Ministry of Water and Energy.

Pender, J., & Gebremedhin, B. (2007). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies, 17*(3), 395–450.

Relief Society of Tigray. (1996). *Raya Valley Development Study Project. Reconnaissance phase report Phase I & volume I, main report.* Mekelle: Relief Society of Tigray.

Shah, T., DebRoy, A., Qureshi, A., & Wang, J. (2003). Sustaining Asia's groundwater boom:. *Resources Forum, 27*, 130–140.

Tesfay, H. (2008). *Impact of irrigation development on poverty reduction in Northern Ethiopia.* Cork: National University of Ireland; Unpublished PhD thesis.

van Steenbergen, F., Kumsa, A., & Al-Awlaki, N. (2015). Understanding Political Will in Groundwater Management: Comparing Yemen and Ethiopia. *Water Alternatives, 8*(1), 774-799.

Wollnia, M., Leeb, D., & Thiesc, J. (2010). Conservation agriculture, organic marketing, and collective action in the Honduran hillsides. *Agricultural Economics, 41*, 373–384.

WWDSE. (2008). *Raya valley pressurized irrigation project Hydrogeology Feasibility study.* Addis Ababa: The Federal Democratic Republic of Ethiopia, Ministry of Water Resource.

Yirga, M. (2011). *Assessment of Cost-Benefit Analysis (CBA) of Ground Water Irrigation Investment in Raya Valley and Kobo Area of Northern Ethiopia.* Mekelle: Mekelle University, Unpublished MSc Thesis.